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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: WESLEY WILKINSON

Serial No.: 08/945,017 Group Art Unit: 3611

Filed: OCTOBER 27, 1997 Examiner: C. BOTTORFF

Title: CONTROL WHEEL ASSEMBLY FOR TROLLEYS

DECLARATION UNDER 37 C.F.R. §1.132

Commissioner for Patents
Washington, D.C. 20231

Sir:

I, Wesley Wilkinson, hereby declare that:

1. I am a citizen of Australia, residing at 28 Bemboka Avenue, Clayton South, Victoria, Australia 3169.

2. I have a Degree of Batchelor of Engineering (Mechanical / Ergonomics) 1985 (Swinburne) and a Graduate Diploma in Risk Management 1989 (Swinburne).

3. I am a qualified Engineer, Ergonomist, and Risk Manager employed by Work Systems Technology Pty. Ltd. (my own company) since August 1994.

4. I am the sole inventor of the above-identified U.S. patent application and make this Declaration in support of the said patent application.

5. DYNAMIC PERFORMANCE COMPARISON

Dynamic performance of typical trolley configurations are compared in Wilkinson, *Integrating Human Factors and Engineering Concepts Into Trolley Design*. A copy of this paper is attached and is incorporated herein by reference. This paper was presented at the Ergonomics Society of Australia conference at the Gold Coast in November 1997. The

paper discusses the dynamic performance of known trolley configurations.

A fifth wheel configuration is defined as means of providing a steering reaction point at the geometric/load center of a castor array/trolley, which may be achieved, for example, by swing arm systems that provide a centrally-located control wheel. The net result, as shown by applied mechanics analysis, is that the steering reaction point for the trolley is provided and eliminates the requirement for users to provide a compromise steering reaction about their spine with the force applied via the feet at the surface interface.

However, prior art solutions to steering problems have provided an answer to only part of the problem: the provision of the steering reaction point in a simplistic two-dimensional or mechanism-restricted three-dimensional terrain. In contrast, the terrain of a typical workplace contains speed humps, ramps, troughs, gutters, and the like. The third axis provided by such difficult terrain over which a trolley is required to travel provides further requirements for a trolley mechanism in order for the trolley to work safely and maintain stability. The prior art solutions have restricted travel via complicated mechanisms. Bottoming out of these mechanisms on ramp peaks and troughs may result in trolleys falling over or loss of control, which may injure the operator.

The added dynamic performance requirements for a trolley, combined with the traction requirements for the control wheel related to the load and surface, demonstrate the deficiencies of known swing arm and mechanical spring systems. In contrast, the claimed trolleys having gas struts are stable on crests and troughs.

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6. <u>COMMERCIAL SUCCESS</u>

The commercial success of the claimed trolleys is demonstrated in niche markets for workplace applications having known injury histories. Difficulty has been experienced in educating potential users that there is a solution to the problems of known trolleys having fifth wheel arrangements such as swing arms and springs.

The claimed trolleys are designed to meet the strict requirements specified in statutory regulations for prevention of manual handling injury. Because the self-contained gas strut provides a key component for elimination of manual handling risks associated with trolley use, the claimed trolleys are being used by the following organizations:

A. <u>Commonwealth Bank of Australia - Australia Wide</u>

Coin trolleys have been specifically designed to address the issues of manual handling of coin (450+ units). The trolleys were introduced into a high risk application of known injury statistics, and high claims cost, with zero incidence of injury after implementation. The trolleys have been accepted as the national standard for the bank. A letter from an employee of the Commonwealth Bank of Australia is attached showing that the claimed trolleys (i.e., Ergo-Sled®) were the only trolleys capable of meeting the bank's performance requirements.

B. <u>Toyota Motor Company of Australia - Port Melbourne</u>

Trolleys have been specifically designed to be towed by battery-powered vehicles to deliver components to production lines. The purpose of the claimed control wheel technology was to eliminate the use of forklifts in the workplace and to prevent worker injury by collision (10 units).

C. Private Hospital Sector - Benchmark Group of Hospitals - Mornington Peninsula - Victoria

The claimed trolleys were introduced to address injury concerns. As a result, a zero incidence of injury associated with the trolleys having self-contained gas struts was achieved. Productivity was also significantly improved since only one worker was required to carry out the same task, which formerly required two workers (20 units). See the attached letter from Mr. Wesley Carter, Deputy CEO of FEGHSS, which shows displacement of other systems by the claimed trolleys. Further, the letter shows the superior benefit that the claimed trolleys have for reducing workplace injuries.

D. PBR Automotive - East Bentleigh Victoria

The claimed trolleys are used for delivery of Kan-Ban parts to production lines (6 units). The trolleys eliminate manual handling difficulties associated with former trolley designs.

E. Parkroyal & Centra Hotels - Various Australia Wide

The claimed trolleys have been introduced into various tasks, including room mini-bar replenishment trolleys (10 units).

7. <u>SUPERIOR RESULTS WITH RESPECT TO INJURY</u>

The superior dynamics provided by the claimed gas strut, combined with the compact simplicity of the design, have resulted in the development of a range of superior trolleys for workplaces where known injury risks exist.

In the attached letter from Ms. Cynthia McQuillan, Chief Executive Office of Beleura private hospital, she states that I began designing trolleys in 1994 to eliminate the neck and shoulder injuries that were occurring among the food service staff at Beleura private hospital. The claimed trolleys having gas struts were shown to Beleura private hospital on or shortly before July 7, 1995, after the filing of the corresponding Australian patent application. As a result of using the claimed trolleys, there have been no further work injuries among the food service staff. The result of using the claimed trolleys has been an extraordinary success as an engineering and occupational health and safety project. In known high risk applications, there has been zero incidence of injury with the claimed trolleys. <u>See also</u> the attached letter from Mr. Wesley Carter.

8. <u>THIRD PARTY OPINION EVIDENCE</u>

Also attached is a letter from Mr. Robert Fallshaw, Managing Director of Fallshaw Wheels & Castors. Mr. Fallshaw states that known trolleys have not been as maneuverable or as capable as being used on rough and unlevel floors as the claimed trolley design by WST (i.e., Work Systems Technology Pty. Ltd.) having a gas strut.

9. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further

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that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: 22/8/2000

WESLEY WILKINSON

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To Whom It May Concern

15 June 2000

The Commonwealth Bank of Australia sought to purchase trolleys that were suitable for the movement of bulk coin within the Branch network.

The Banks performance requirements included :

1. Steering forces should be at zero to start and no greater than 20N during movement with a 100 kg load.

2. Steering forces must be at zero when travelling in a straight line and across slopes.

3. A minimum design load capacity of 500 kg.

4. Castors designed to operate on a carpeted floor surface.

5. Handle design which provides optimum posture for pushing.

6. Trolley base no greater than 900 x 570mm.

The Ergo-Sled® designed by Trolley Solutions International Pty Ltd was the only trolley capable of meeting the Bank's requirements. The Ergo-Sled's fifth wheel concept allows the trolley to be easily pushed and steered simultaneously, particularly within the space limitations of a bank branch. Trolley Solutions International has specifically modified the Ergo-Sled ® to suit the performance requirements and conditions within the Bank.

Yours sincerely

C M Bray
Adviser
Safe Work Systems

To Whom It May Concern,

Re: 5 Wheel Trolley

Some time ago, as Hotel Services Manager for the Bays Hospital Group Inc, I explored the market for alternative trolleys to use for the meal distribution function. After much market research the 5-wheel trolley was trialed introduced. Having assessed the workplace prior to the introduction of the trolleys, we then set about monitoring and assessing the situation during and after the introduction of the 5 wheeled trolleys. It met and exceeded our expectations.

Work place injuries caused from the meal trolley was greatly reduced. In fact the 2 instances that occurred during the 3-month monitoring period were operator caused and were not the fault of the trolley.

The key success of this trolley I believe is the integral gas strut in the middle of the trolley, or in simpler terms the fifth wheel.

More recently I was confronted with the same situation at Bethlehem Hospital, where this time the first and only choice was to introduce the 5-wheel trolley from Trolley Solutions International. My current position at the Orbost Hospital not only involves the kitchen area but also a broader area incorporating OH&S. One of my first tasks will be to review ALL the trolleys used at this site and where necessary introduce this technology.

I would certainly recommend these trolley for implementation into any suitable application where reducing workplace injuries are an issue.

Should you wish to talk to me about these trolleys please contact me on 0438 546 609.

Wesley Carter
Deputy CEO
FEGHSS

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16th August 2000

TO WHOM IT MAY CONCERN

In 1994 Beleura Private Hospital was getting workcover claims from its food service staff who were responsible for the delivery of patient meals. In consultation with an ergonomist, we found that our existing food delivery trolleys were causing the neck and shoulder injuries.

As there was nothing on the market that would eliminate the injuries, we decided to work together with Wes Wilkinson and for him to design, build and then trial the purpose built food delivery trolleys at Beleura.

Wes developed a trolley with a 5th wheel and an integral gas strutt. The trolleys were so succesful that we replaced all of our existing food trolleys with the newly designed and purpose built trolley. We also purchased 3 linen trolleys with the same 5th wheel concept.

Over the past six years of using these trolleys, we have had no further workcover injuries from the staff who deliver the meals.

If the reader would like to discuss our experience with working with Wes Wilkinson and Trolley Solutions, I can be reached Monday to Friday from 9am to 5pm on (03) 59758755

Yours sincerely
Beleura Private Hospital

Cynthia McQuillan
Chief Executive Officer

FALLSHAW WHEELS & CASTORS
we've re-invented the wheel

15 June 2000

Attention: To Whom it May Concern

Work Systems Technology Pty Ltd has invented a substantial improvement for wheeled trolleys with its '5th Wheel' concept.

This can easily be seen in two ways:

- Use a heavily loaded trolley fitted with one of their designs of 5th wheel – you will find it so much easier to use than other designs.
- Then try and find anyone else who has their design – you will not, because they were first. *(This can be checked by looking in numerous castor catalogues in the section on 'Using/ Mounting Castors').*

As a wheel and castor maker for 35 years, and one who sells world wide, I am very aware of trolley design, and I have written a booklet called 'Designing Trolleys' to assist with the proper and effective use of castors. This was first written in 1987 and revised in 1995. Yet, when I first saw the WST 5th wheel *design (approx 1998)* I said " Wow!"

There have been previous attempts to use the 5th wheel. However, these have been side mounted and manually engaged, and not centrally placed and not biased by means of a gas strut. The consequence has been that they have only worked on level floors, and have not been as manoeuvrable; while the WST design can be used widely in industry on rough and unlevel floors, as well as conveniently.

I have been most impressed. Wheels have a history of 5000 years, and the trolleys they are used on have settled in to established patterns. It is seldom I am moved to surprise and delight.

R. Fallshaw

Robert Fallshaw

Managing Director

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INTEGRATING HUMAN FACTORS AND ENGINEERING CONCEPTS INTO TROLLEY DESIGN

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ABSTRACT

Trolley design has been of concern to industry and society for generations with trolleys used for ease of transportation of any type of object. Perhaps one of the most infamous examples is that of the shopping trolley. The concerns are related to a number of Ergonomic factors including the difficulty associated with steering a trolley with all swivel castors, excessive steering and operating forces, the inadequacy of the handles provided to interface with the user and the poor ergonomic design of the load space. Add irregular or carpeted surfaces and the problems are further compounded.

Research into trolley design began as part of a consultancy project for a client with significant history of worker injury related to trolley use. Maximum forces related to the potential population of users were determined to assist with defining the problem. A first principles approach to the design was taken involving analysis of the forces involved in moving and steering trolleys. It was found that of the many factors affecting the trolley's dynamics the unresolved steering forces in the chassis were the major issue.

A prototype trolley was manufactured to demonstrate the concepts of steering chassis design, ergonomically designed handles and load spaces. Further prototypes were manufactured to suit a number of tasks with the outcome being the commercial manufacture of a range of trolleys using the generic chassis which evolved from the project.

Key Words: trolley design, engineering, human factors, ergonomics

1.0 INTRODUCTION

Several industry groups use trolleys as a key part of the daily task of transporting goods and equipment from location to location. Historically the design of trolleys has been extremely deficient with the design based around placing four wheels on a frame which is loaded to capacity with little consideration for the requirements of the user. The research for this paper has its origins in the hospital sector where trolleys are used to move almost every object within the hospital. Workers in the food service area in particular were experiencing pain and in some cases developing injuries resulting from the use of the trolleys provided. An analysis of the situation was completed to determine appropriate solutions. The development has branched into other areas.

2.0 METHOD

The analysis of the problem involved firstly defining the problem. Workers using the equipment were interviewed and their concerns recorded.
Typical comments were:

- that the trolleys were difficult to steer and push,
- two people were required to do the job,
- the trolley was awkward to push in relation to the position of the handles - not everyone could use them,
- the trolley was even more difficult to push and steer on carpet,
- it was difficult to negotiate sideways grades without the trolley running down the grade,
- difficulty in negotiating doorways and narrow clearances,
- load storage positions were too high or too low,
- wheels keep jamming or seizing.

Operating forces were measured as the component forces eg. starting force, rolling force, steering force.
Analysis of the forces acting on the trolley chassis was carried out to determine the reasons for certain dynamic performance problems as reported by operators.
To facilitate problem solving, concerns were separated as follows:

- chassis dynamics
- castor design / selection
- floor surface
- handle design
- task / load space design

Once broken down into components it was clear that major modifications to the design of the existing trolleys were required.

3.0 RESULTS

CHASSIS DYNAMICS

Analysis of the forces acting on a trolley chassis with four castors indicated that the reason for a trolley's dynamic handling concerns was that there were unresolved forces acting on the trolley which required counter forces to be applied by the user to maintain a straight course on a grade or to correct the direction of travel. The correction / restraining forces which often require sustained static muscle activity are applied about the centre of the operators body in the absence of any other reaction point and can result in serious injury. Damaged castors may also add an unresolved force into the arrangement. The test results clearly showed that whilst the forces involved in pushing a trolley were a concern with castor / floor surface combinations determining the performance, the usually coincident steering forces required for a trolley with four castors were the major source of difficulty, that is, the self steering effect of a four wheel castor chassis.

FIGURE 1 details the action of the forces of a four castor trolley on a slope:

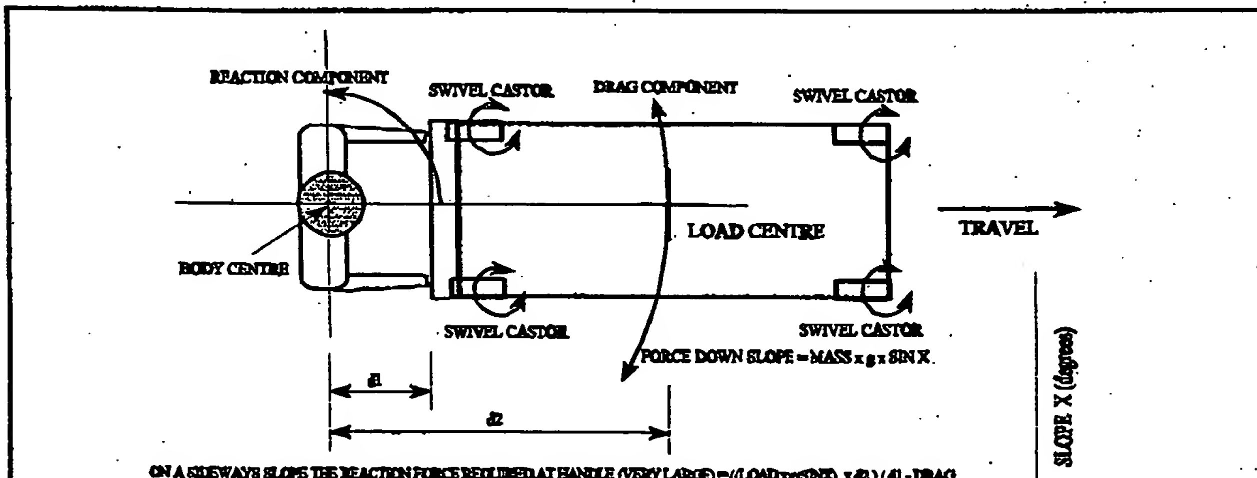

FIGURE 1
PLAN VIEW - CHASSIS WITH FOUR CASTORS ON SIDEWAYS SLOPE

Various configurations for steering trolleys have been tried over the past few decades with little or no success. Trolleys which have fixed rear wheels and front castors with the load centre in between, become increasingly more difficult to steer as the load increases and even more difficult on grades. This results from the load creating a large moment about the fixed rear wheels given its distance in front of the rear axle (the steering axis) with only a small restraining moment possible from the operator (due to small distance from handle to steering axis). This is characteristic of the behaviour of the latest range of modified shopping trolleys, thus the problems of manoeuvrability have only been compounded. Refer Figure 2.

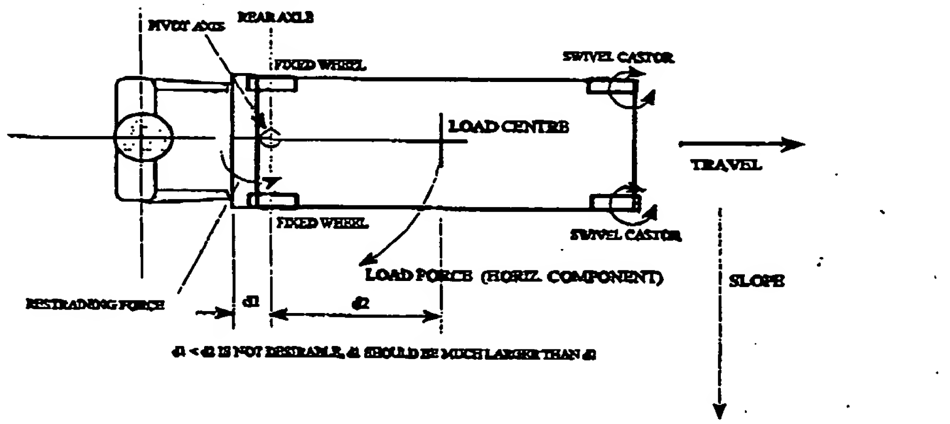

FIGURE 2
PLAN VIEW : TROLLEY WITH FIXED REAR WHEELS ON A SLOPE eg. SOME SHOPPING TROLLEYS

The same concern arises for trolleys with fixed front wheels however it is easier to counteract the load moment effect on grades due to the longer moment arm (length of trolley). Chassis which self steer in a straight line are an advantage however manoeuvrability concerns are an issue dependent on the configuration. Market type trolleys with their centre axle carrying the weight are easily manoeuvred, however instability is a concern with the rocking action of the trolley to either end.

Recent tests using shopping trolleys have been used to provide the data tabulated in Table 1. The measurements were made with the trolleys on smooth concrete, forces would be expected to be at least 50 percent higher on carpet. The tabulated results indicate the force variations for steering versus all castor trolleys.

TABLE 1. TROLLEY OPERATING FORCES:

FORCE (Newtons)	PUSHING	PUSHING	STEERING	STEERING
TROLLEY CONFIG'N / ACTION	4 CASTORS NO STEERING * **	2 CASTORS 2 FIXED (REAR) * ***	4 CASTORS NO STEERING * **	2 CASTORS 2 FIXED (REAR) * ***
START No Load	4	4	-	-
ROLL No Load	2	2	13	10
START Load 100kg	16	16	-	-
ROLL Load 100kg	10	10	90 *	35*

* Extra force component on grades adds restraining force and increases steering force for operator
** Steering pivot (all castors) is the centre line of the operators body (450mm from handle)
*** Steering pivot for a trolley with fixed rear wheels is effectively the Centre of the rear axle.
Forces measured at existing handles.

Operating forces for steering trolleys were measured and the results tabulated in Table 2. The results show clear differences between steering and all-castor trolleys.

TABLE 2. TROLLEY OPERATING FORCES - ALL CASTORS VERSUS STEERING TROLLEYS:

FORCE (Newtons)	PUSHING	PUSHING	PUSHING	STEERING	STEERING	STEERING
TROLLEY CONFIG'N >	4 CASTORS	2 CASTORS 2 FIXED (REAR)	5 TH WHEEL FITTED	4 CASTORS NO STEERING	2 CASTORS 2 FIXED (REAR)	FIFTH WHEEL FITTED
ACTION V	* **	* ***		* **	* ***	
START (No Load)	4	4	4	-	-	-
ROLL (No Load)	2	2	2	13	10	6
START (Load 100kg)	16	16	16	-	-	-
ROLL (Load 100kg)	10	10	10	90**	35***	16

*Extra force component on grades adds restraining force and Increases steering force for operator
** Steering pivot for an all castor trolley is the centre line of the operators body (450mm from handle)
*** Steering pivot for a trolley with fixed rear wheels is effectively the centre of the rear axle.
Forces measured at existing handles.

The shaded section of the table clearly shows the difference between the various steering options with the fifth wheel trolley requiring approximately 1/6th of the steering force of an all castor trolley. It should be noted that all trolleys have high castor turn around forces (force to turn castor 180 degrees) however this can be overcome on a fifth wheel trolley by utilising the steering pivot action to turn the castor before moving the trolley.

Castor manufacturers provide configuration advice for customers however most configurations have deficiencies. Fifth wheel configurations address the issue of the unresolved forces, manoeuvrability, etc. however the trolley cannot cope with the crest at the top of a ramp and the trough at the bottom. Trolleys tended to fall over at the crest of the ramps. Existing Patents on fifth wheel systems have been too complex impractical to manufacture and have not reached commercial reality. The only movement a fifth wheel trolley does not effectively achieve is sideways travel.

CASTOR DESIGN AND SELECTION

Castor design is important to the overall forces acting on a trolley however only limited improvement can be achieved through using better designed and higher quality castors. Lower rolling forces result from better quality bearings and appropriate tyre material for the surface of the intended application. Tyre section / profile can effect the turn around performance (castor effect) and rolling resistance depending on the floor surface however our tests could not confirm the claim by a leading castor manufacturer that a round section tyre turned better on carpet, to the contrary we found that a flat section tyre turned easier. Castor angles determine the turn around performance of the castor. Tests conducted on castors greater than 150mm have shown that castor turn around forces increase due to the effect of the larger distance from the floor to the swivel giving a greater moment about the swivel in a plane perpendicular to the axis of swivel rotation tending to lock the swivel action of the castor (wants to push the castor over rather than swivel it). The effect is particularly pronounced on carpet.

Castor maintenance is also an important criteria.

FLOOR SURFACE

Floor surface effects the performance of castors significantly. Hard, smooth surfaces promote easy rolling of castors whereas rough or rutted surfaces, joins in surfaces etc. produce peaks in force requirements. Soft surfaces eg. carpeted surfaces with underlay provide constant drag for the wheels which can increase pushing forces by up to 50%. Other concerns with floor surfaces relate to noise emitted by the castors dependent on tyre type. Selection of castors must consider floor surface type.

HANDLE DESIGN

Handle design is a significant contributor to the difficulty associated with trolley interaction. The application of forces to what are considered to be suitable handles in the trolley industry is difficult. The handles are usually a fixed height horizontal bar catering for only a very small range of user population. The handle does not promote optimum application of forces for pushing and uses a compromised, rotated inappropriate wrist posture.

Given that trolleys used in a work situation in industry may be used by a large range of users of differing stature, the current designs used are unsuitable. Reference to Human Scale indicated that the design of the existing handles and in fact most trolley handles did not cater for a range of users and utilised the wrong wrist postures for pushing.

TASK LOAD SPACE DESIGN

Load space design on trolleys has been typically an exercise of fitting the maximum amount of material into the available space without consideration of the variation in stature of the user group and the other ergonomic requirements of the task. Examples of existing designs show load space locations well above the range of vision and even above shoulder / head height. eg. hospital meals trolleys. Reference to the Manual Handling Regulations and Code of Practice 1988 (VIC) confirmed that the existing design of the trolley load spaces did not consider upper and lower storage location limits.

PROTOTYPE TROLLEYS:

An initial trolley chassis design incorporating a fifth wheel system was experimented with to ascertain whether the effect resolved all of the issues. On a flat surface the trolley demonstrated that it could be easily steered and in fact only required pointing in the desired direction of travel and pushing. The trolley did however become unstable on bumps and crests when the weight of the trolley rested on the fifth wheel. Experimentation with the dynamics and design of the fifth wheel has resulted in a mechanism which does not support the trolley but effectively steers the trolley whilst overcoming all of the concerns previously experienced with performance with the added bonus of being easily manufactured. The resultant system has been patented in Australia and overseas.

Prototype trolleys have been fitted with handles that provide the optimum posture for pushing for a user population of 95 % whilst also providing a neutral wrist posture. The handle design also provides slightly greater steering advantage for the shorter stature operators than the larger users. (The handles developed are registered designs).

It is also important to consider the variation of strength within the user population. Table 3. details the limits for applied pushing forces. Load spaces have been configured to the requirements of the task after first carrying out a task analysis with the user group. In a true prototyping fashion the end result is a refined version of the prototype.

4.0 DISCUSSION

Measurements of forces associated with using a trolley fitted with a fifth wheel system have confirmed that without the excessive steering forces a trolley is easy to use ie. there is no requirement to push the trolley and restrain its motion in directions other than the direction of travel. The most notable example of this behaviour is that of the shopping trolley on the mandatory grade outside every supermarket. With only the motive force to concern the operator, the task moving a fifth wheel trolley is simply to overcome the rolling resistance of the loaded trolley. The force measurements in Table 2. confirm the results comprehensively. Further proof of the effectiveness of the design is that a 1 year old infant can move and steer a fifth wheel trolley.

The generic chassis has since been developed for industrial, hotel and office applications.

It is also important to note that the trolley is only one component in a manual handling system and as such it is essential that the various components are matched so as to create a manual handling system rather than a trolley poorly interfaced with a workplace. Considerations such as location of stored items both geographic and specific (vertical/horizontal). Location of frequently accessed objects versus infrequently accessed objects with consideration for the mass of the object.

5.0 CONCLUSIONS

Procurement of a trolley is therefore not just a matter of selection of a suitable trolley from a catalogue.

The selection of the trolley becomes critical in high usage applications where the user may experience a serious injury if a poorly designed unit is purchased. An injury will have significant impact under Workers Compensation insurance and result in higher premiums that far outweigh the cost of purchasing a properly designed unit.

A thorough understanding of the task requirements associated with the trolley application is necessary prior to sourcing the market for available units. It is advisable to prepare a specification for the unit remembering that the trolley is part of a system.

6.0 RECOMMENDATIONS

It is recommended that the following approach be utilised to specify the design of trolleys prior to purchasing

- Carry out task analysis including all components of the system of work associated with the trolley,
- Assess floor surface/s trolley is to operate on,
- Carefully select steering chassis configurations in preference to non-steering chassis configurations,
- Select castor type dependent on floor surface, load, performance requirements,
- Utilise correctly designed handles,
- Design load spaces in accordance with Manual Handling standards, avoid storage locations above shoulder height and below knee height,
- Design task around manual handling and operator force application requirements ie. strength limitations (Refer Table 3),
- Design trolleys to be correctly interfaced and integrated as part of a manual handling system,
- Comply with the requirements of the environment in which the unit will be used eg. infection control in medical facilities requires certain materials to be used and certain component configurations to be avoided,
- Floor surfaces should have any irregularities repaired and floor covering edges tapered out or eliminated.,
- Monitor feedback from user groups.

TABLE 3: RECOMMENDED MAXIMUM OPERATING FORCES FOR TROLLEYS

OPERATOR	STARTING FORCE MAXIMUM FORCE (1-5 SEC DURATION WITHOUT STRAIN)	PUSHING FORCE SUSTAINED FORCE (LONG DURATION & FREQ. INTERMITTENT USE)
2.5 %ile Fe (SMALL FEMALE)	10 kg (10kgF ~100Newtons)	4.0 kg
2.5 %ile M (SMALL MALE)	15kg	6 kg
97.5 %ile Fe (LARGE FEMALE)	30kg	11 kg
97.5 %ile M (LARGE MALE)	46 kg	17 kg
Trolley Solutions International P/L COPYRIGHT © August 1996		

7.0 REFERENCES

Victorian Workcover Authority, 1988, Manual Handling Regulations & Code of Practice
Diffrient, N. et al, 1974, HUMANSCALE 1 - 9 Manual, MIT Press, Cambridge, Massachusetts.